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APPLICATION OF 3D CAD AS A BUSINESS-LEVEL STRATEGY IN THE MECHANICAL SERVICES INDUSTRY

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ABSTRACT

The crucial role 3D CAD in product design is well established. However, opportunities remain across the industrial sector for harnessing the competitive advantages offered by the adoption of 3D CAD technology. This paper reports on the benefits and advantages gained from the implementation of the technology in the precision mechanical installation/handling sector. Central to this is embedding the capability to develop clear 3D models of handling solutions, integrated with static and dynamic simulation for structural verification. The smooth integration of customer product data has helped to shorten lead times, increase confidence in solutions and reduce costs. Case studies from a KTP programme between Ulster University and MIM (NI) Ltd. are presented to illustrate how the implementation of 3D design has enabled the company to win higher value-added business, has helped differentiate itself from its competitors and establish itself as a market leader in this sector.

KEYWORDS: CAD, 3-D modelling, visualisation

1. INTRODUCTION

Mechanical Installations & Maintenance (NI), MIM, was established 20 years ago in Maydown, on the outskirts of Derry~Londonderry. It is a private limited company with a workforce of approximately 40. MIM offers a wide range of specialist services including; machinery installation, plant maintenance, decommissioning and plant relocation, lifting, testing and certification, and optical/laser alignment. The company also has a well-equipped workshop, giving it the ability to undertake sheet metal fabrication, structural steel work, and the manufacture of machine sub-assemblies.

Customers range from manufacturing companies such as DuPont, Perfect Seal, Seagate and E&I Engineering to utilities such as the ESB and to government bodies, such as Transport NI and NI Water. MIM originally created their concept sketches and engineering drawings on drawing boards. Following the economic downturn several years ago, the company began liaising with design firms to produce 2D CAD drawings in order to become more competitive. 2D CAD enabled the production of more professional looking designs in a shorter lead

time. In time, MIM developed the capability to produce 2D CAD in-house and retained specialist design firms for some aspects of design validation.

To strengthen its competitive position, MIM partnered with Ulster University to established Knowledge Transfer Partnership (KTP) to develop MIM's capability to respond quickly with well-engineered solutions to what are frequently one-off problems. One objective of the KTP is to create an in-house 3D design capability to facilitate a formal and efficient structured approach to the design and execution of projects.

2. 3D CAD APPLICATIONS

The crucial role of 3D CAD in the life-cycle of manufactured products is well established. The effective use of 3D CAD in bespoke design and in construction-related activities is a rapidly evolving topic and offers the potential for similar benefits. According to Clayton et al. [1] the introduction of 3D modelling and computer simulation enabled architecture students to gain a deeper understanding of the relationship between the design and construction of buildings. White et al. [2] foresaw the potential of virtual reality systems for improving building design and construction, and advocated for its more widespread use. Their investigation revealed that data translation from traditional CAD to virtual reality systems was a major obstacle to widespread use. Furthermore the data flow in this approach was limited to a one way process.

Park et al. [3] reported on studies that have shown that 3D and 4D CAD had positively impacted on the productivity and safety of construction processes. 35 application areas for 3D/4D CAD were identified, though the majority were in the design and construction phases. Benefits from the application of the technology included the improved ability to exchange complex ideas among project participants, and the ease of generation and re-use of 3D information in construction projects. Project management information is now widely embedded in 3D CAD models. The extension to 4D CAD, that enables visualisation of sequential construction processes, was assessed by the authors as being of well suited to the requirements of the design and construction phases. The study concluded that there exists a need to expand the functionality of 3D/4D technologies to include more planning, operation and maintenance, and life-cycle management processes.

Recent developments in additive manufacturing technologies have allowed for the cost-effective printing of 3D CAD models. As described above, 3D CAD offers huge benefits in the clear communication of ideas between interested parties. Dadi et al. [4] conducted a cognitive experiment to measure the effectiveness of 2D drawings, a 3D computer model and a 3D printed model in delivering engineering information to an end-user. The study concluded that the 3D printed model outperformed the 2D drawing and the 3D computer interface in productivity measures.

A review of 3D modelling packages concluded in the selection of SolidWorks as the preferred package. The introduction of 3D CAD as a key element in MIM's business model and the benefits accruing are described in the following section.

3. 3D CAD AS A BUSINESS STRATEGY IN MIM

3.1 Turbine Lifting Frame

Given MIM's wide target market and the range of services it offers, it is not surprising that the company regularly receives requests for solutions to one-off engineering problems. Time is typically a very important factor for the customer. As a multi-stage process, the ability to respond quickly with a quote is a critical success factor in winning business. A typical example of this, a rig to lift a turbine, is shown in Figure 1. The ability to quickly generate and clearly communicate to the customer the proposed solution were order winners.

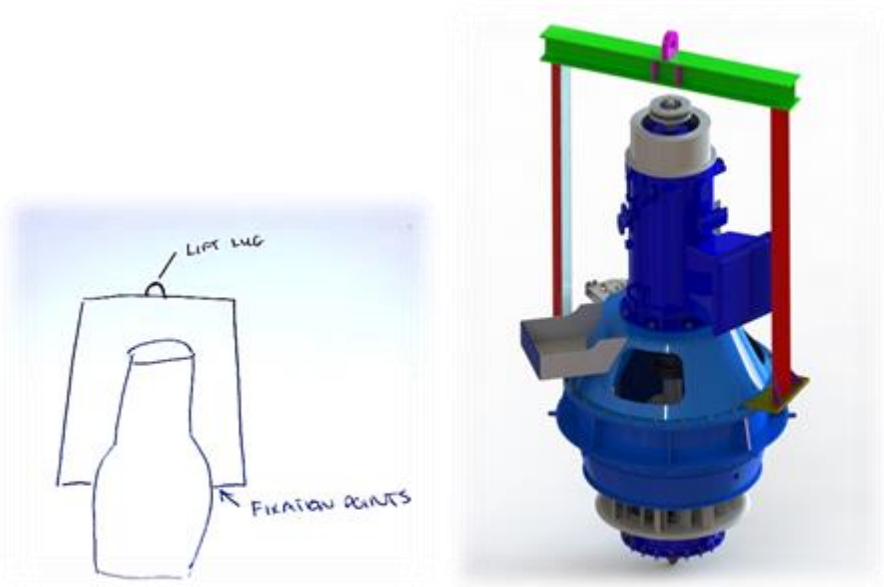


Figure 1: Initial concept (left) and proposed solution presented to the customer (right)

The lifting rig was designed, built, tested and in use within three days. This would have been extremely difficult to achieve without the benefits of in-house 3D CAD modelling. The design process was greatly accelerated through the integration of the customer's part file of the turbine into the development and detailing of the solution. Figure 2 illustrates how details of the fixing points, for example, could be readily aligned in the lifting rig.

During the design process, interference and collision features in SolidWorks helped get the design right first time. Once the 3D model was verified, manufacturing drawings from these part files could then be easily generated for the workshop. In this case the frame was manufactured and tested within 1 day, whereas before would have taken approximately 2 weeks to complete.

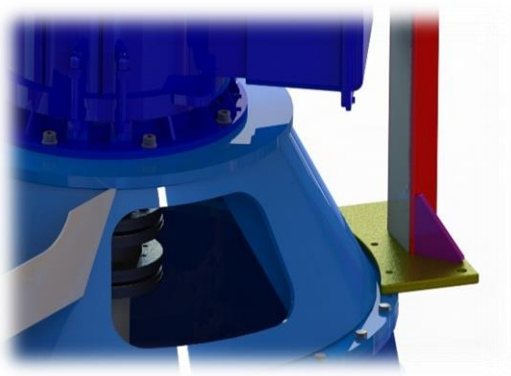


Figure 2: Detail of fixing points

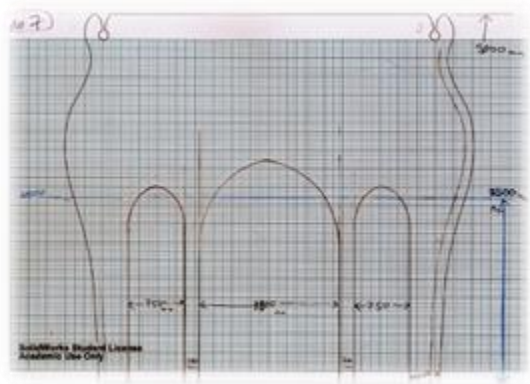
The images contained in Figure 3 show the solution successfully in action on the third day. The success of this project led directly to MIM securing several other jobs with this new customer.

Figure 3: Lifting rig in operation

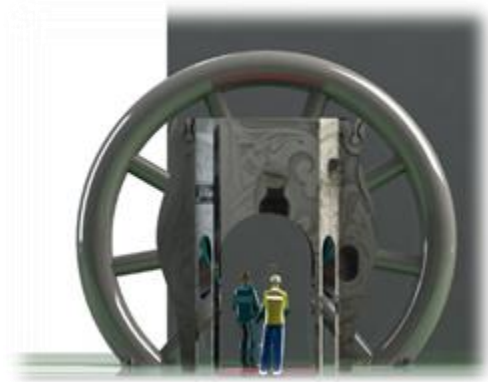
3.2 Public Artwork

A growing segment of MIM's business involves working with artists on public art projects. For these projects, SolidWorks' rendering capability to produce almost life-like drawings has been invaluable to MIM winning work in this area, for example in public sculpture projects. Working alongside the artist and understanding the artist's intent in a work of art is essential to manufacturing a creative sculpture design. The engineer can create a visualisation that can be easily communicated to the artist and become the object that links the engineering understanding of the project to the artistic vision that the artist has. Figure 4 below illustrates how cardboard models and sketches that are produced by the artist can quickly be translated into a 3D CAD assembly where relative size and scale can be confirmed.

Cost is normally a significant consideration in these projects. 3D CAD greatly facilitated the production of an accurate quotation. It also helped the engineer reduce material costs at the design stage by optimising the sheet metal sheet sizes. Finally the 3D CAD models can easily generate engineering drawings for the workshop.



(a)



(b)

Figure 4: Concept sketch (a) and 3D rendered image (b)

SolidWorks also has the capability of generating STL files for creating 3D printed models. Given the advantages of 3D printed models identified by Dadi et al. [4], MIM is currently exploring the potential of this technology in this and other segments of its market.

3.3 Lifting Department – Beams

A major MIM competency is its lifting division that offers customers design, fabrications and certification of lifting equipment. Customers require lifting beams, chains, davit arms to be certified to lift a specified safe working load. These beams are manufactured and physically tested in-house under specified loading conditions. Not only does MIM have the capability to physically test lifting equipment but now with the simulation features of SolidWorks, MIM can conduct static linear simulation on structures to quickly predict performance and behaviour such as von Mises stress, displacement and safe working load before any material is even sourced never mind cut and tested. Figure 5 shows an example of the simulated load analysis of a fabricated steel lifting frame project.

This capability has proven to be invaluable to the sales and marketing of the company's lifting department too as customers are more confident on account

of the added reassurance that not only are rigs tested physically but the design and test loading conditions can be simulated virtually as well.

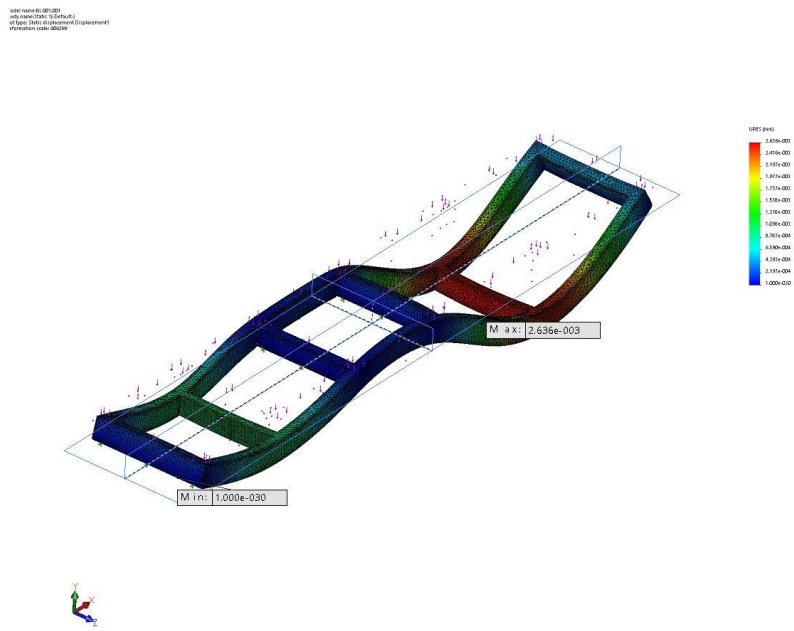


Figure 5: Simulated loading of lifting rig

4. CONCLUSION

The case studies outlined above clearly demonstrate the benefits to MIM's business of implementing 3D CAD modelling capability. It has enabled a faster, more professional response to customers and helped MIM successfully win new business. Central to this is embedding the capability to develop clear 3D models of handling solutions, integrated with static and dynamic simulation for structural verification. The smooth integration of customer product data has helped to shorten lead times, increase confidence in solutions and reduce costs. Further productivity gains are expected through the creation of a parts library or a catalogue of parts that may be used repeatedly in developing solutions for projects in the lifting department, thus elimination the need of having to design similar parts over and over again. It will also mean that design time will be further reduced and help achieve shorter job turnaround times.

The initial investment of £10,000 in 3D CAD has, in just 6 months, resulted in winning £50,000 new business and an increase of 5% in the workforce.

The next phase of the programme will embed 3D CAD modelling capability within MIM's core design team so that the gains become both sustainable and more widespread.

The introduction of 3D CAD had led to immediate productivity gains and to new business opportunities. The ability of the 3D CAD package to produce very professional images is also contributing to the company's marketing

activities and has resulted in recognition of successfully completed projects in local newspapers, investment award communities and also on social media, leading to new business contacts.

ACKNOWLWDGEMENTS

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